National Aeronautics and Space Administration

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SPACE LAUNCH SYSTEM

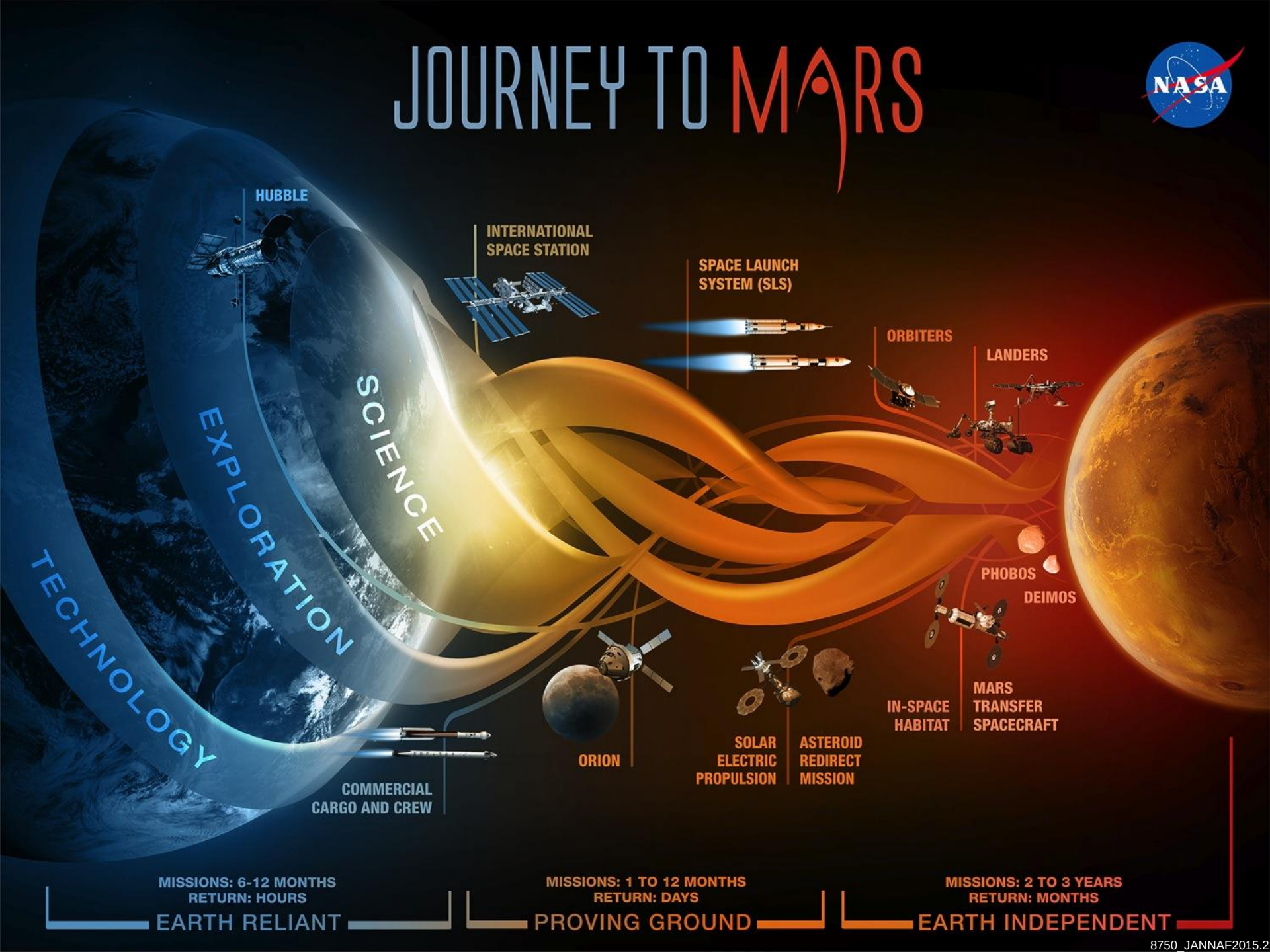
Bob Hawkins
Deputy Lead Engineer
SLS Integrated Avionics and Software

Exploration Class Capability for Deep Space Exploration

SLS SPACE LAUNCH SYSTEM

www.nasa.gov/sls

JOURNEY TO MARS



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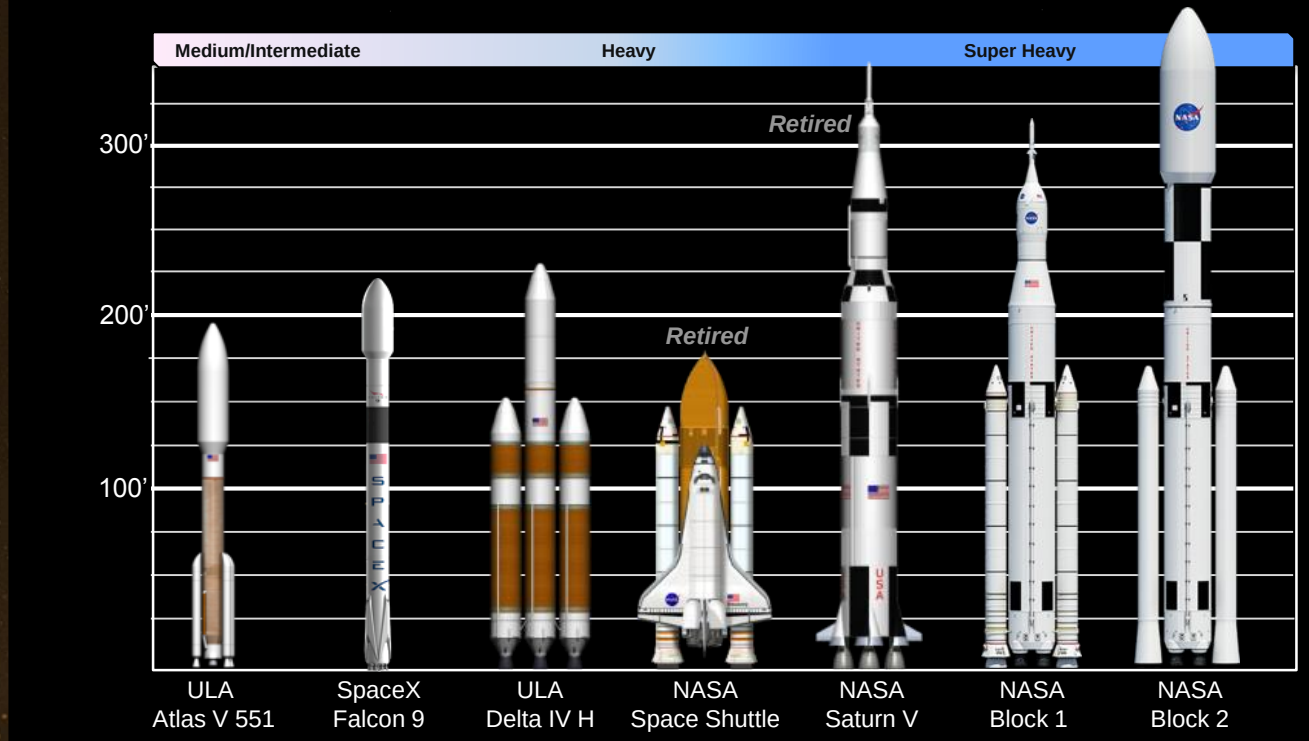
SLS Driving Objectives

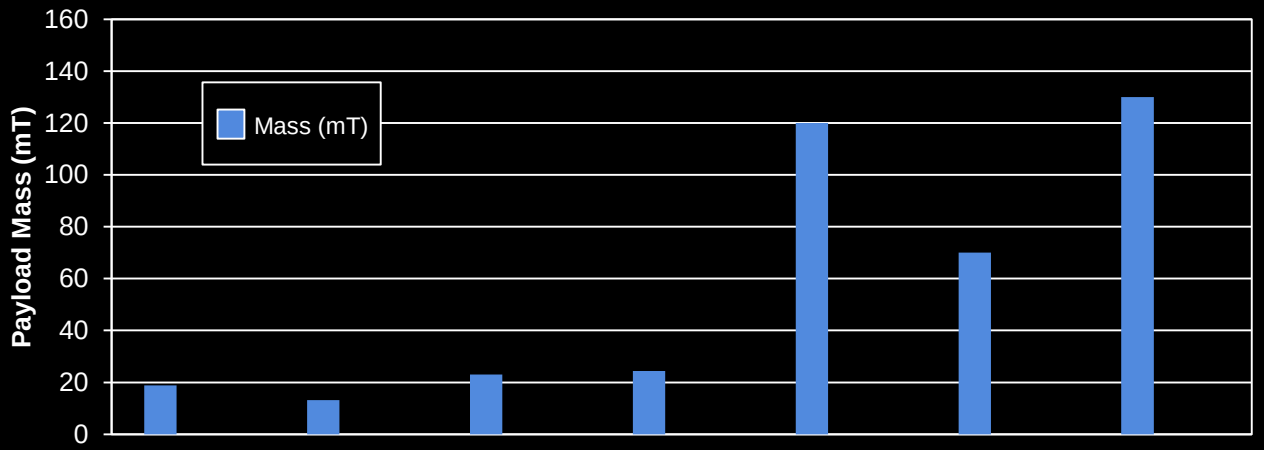
- **Safe**
  - Human-rated to provide safe and reliable systems
  - Protecting the public, NASA workforce, high-value equipment and property, and the environment from potential harm
- **Affordable**
  - Maximum use of common elements and existing assets, infrastructure, and workforce
  - Constrained budget environment
  - Competitive opportunities for affordability on-ramps
- **Sustainable**
  - Initial capability: 70 metric tons (t), 2017–2021
    - Serves as primary transportation for Orion and human exploration missions
  - Evolved capability: 105 t and 130 t, post-2021
    - Offers large volume for science missions and payloads
    - Reduces trip times to get science results faster
    - Minimizes risk of radiation exposure and orbital debris impacts

Designed for BEO Missions of National Importance

SLS Mass-to-Orbit Comparison

- SLS initial configuration offers Block 1 to LEO.
- Future configurations offer Block 1B and Block 2 to LEO.
- More mass-to-orbit means larger payloads to variety of destinations.

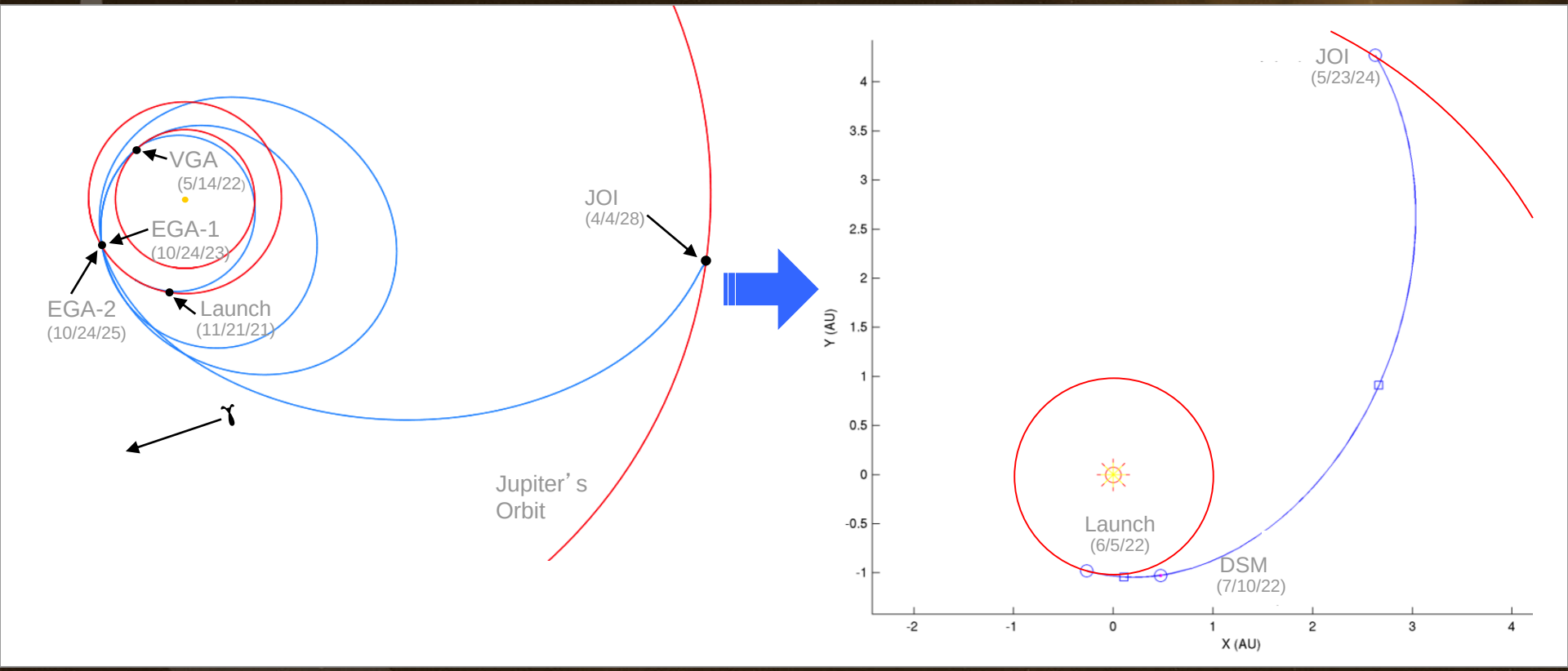




Europa Trajectory Comparison

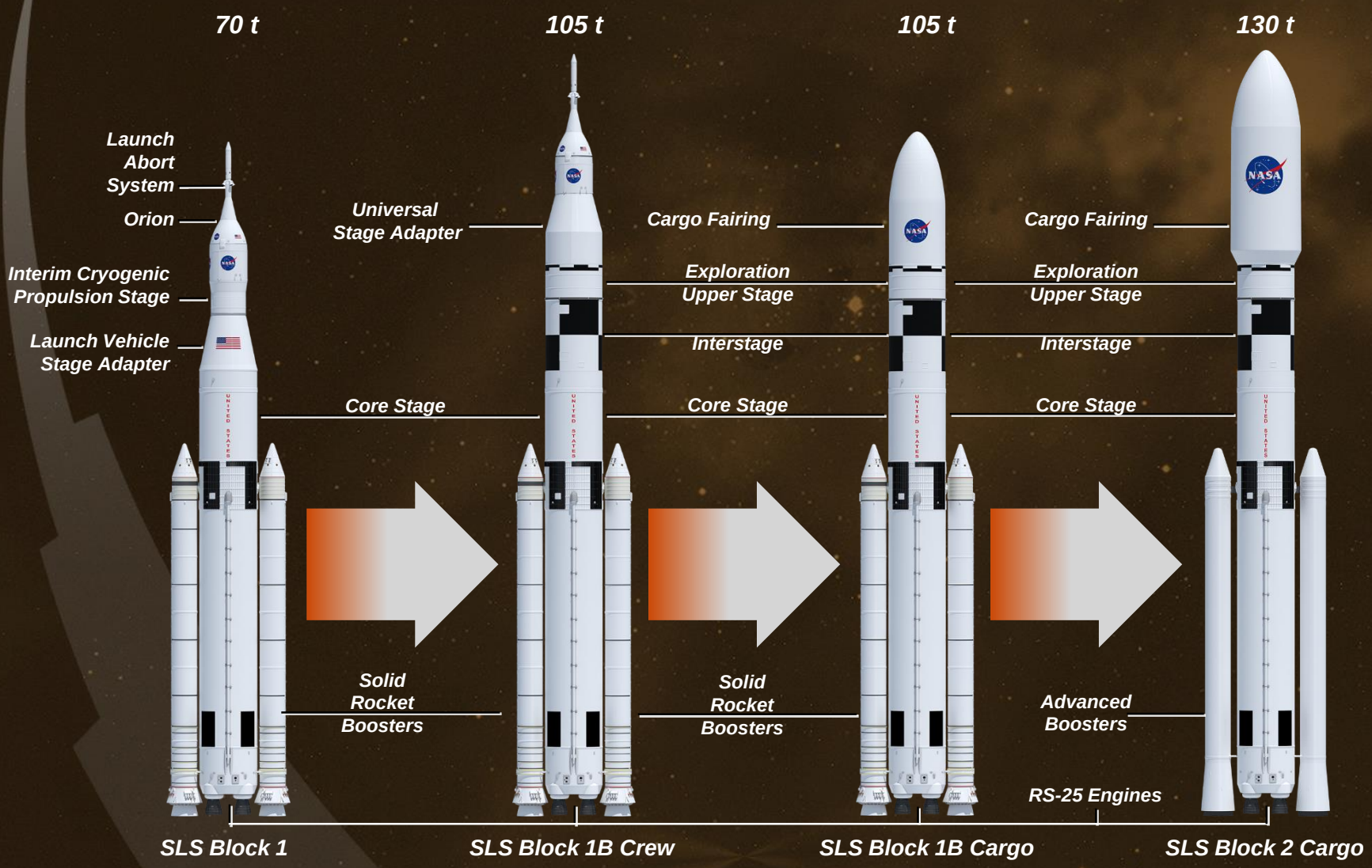
Atlas V 551: VEEGA

SLS: Direct

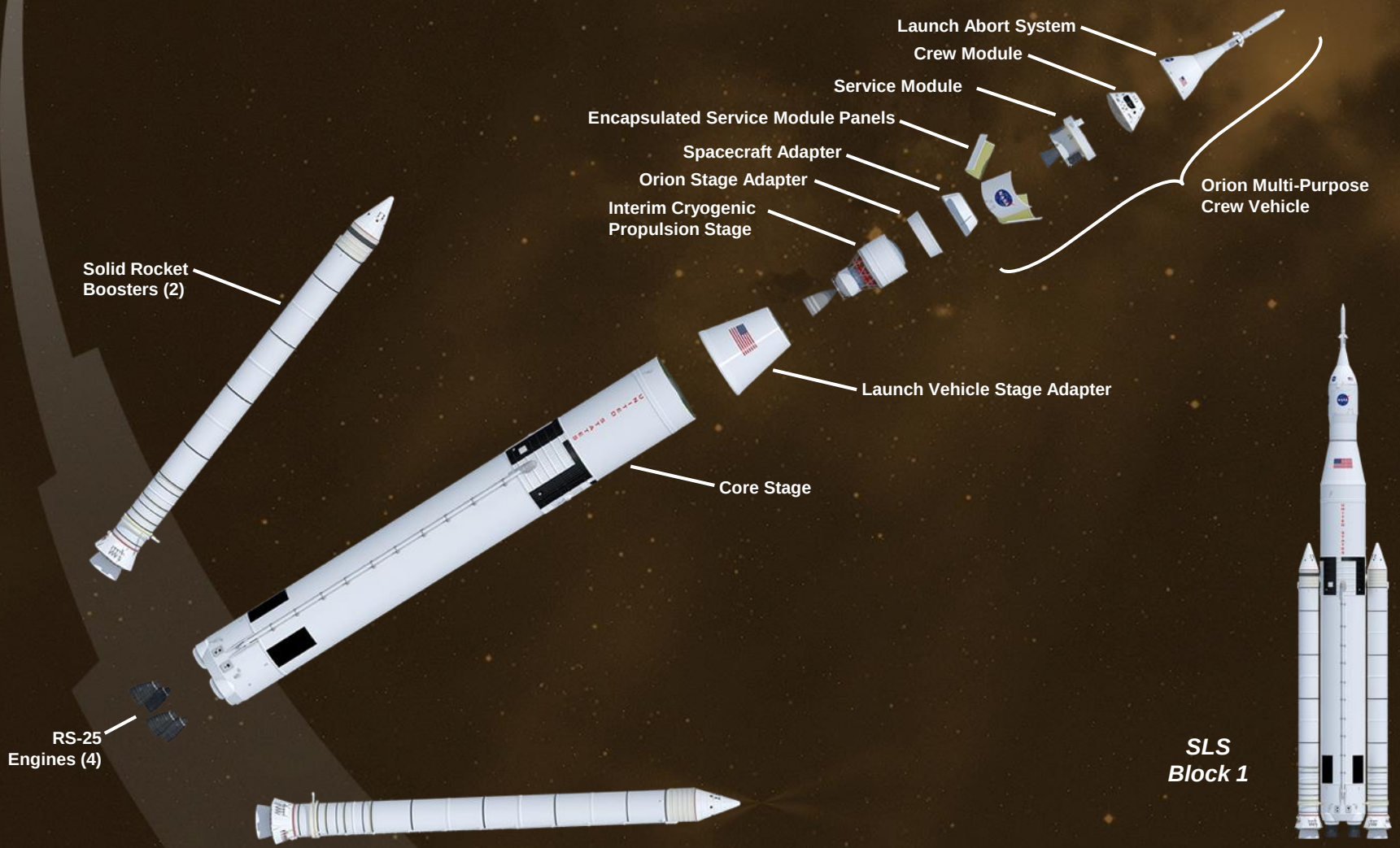


Reduces Transit Time To Europa By Half

SLS Evolution Overview

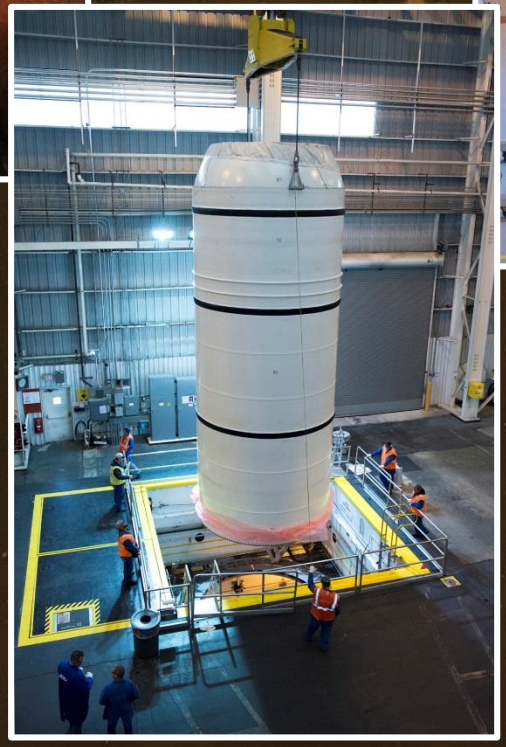


SLS Block 1 Key Design Features



Five-Segment Solid Rocket Booster

Qualification Motor-1 (QM-1)
March 2015, Promontory, Utah



Booster Processing,
Promontory, Utah

SRB Forward Skirt Load Test
May 2014, Promontory Utah

SRB Aft Skirt Avionics Testing
September 2014

5-Segment Booster Test Video

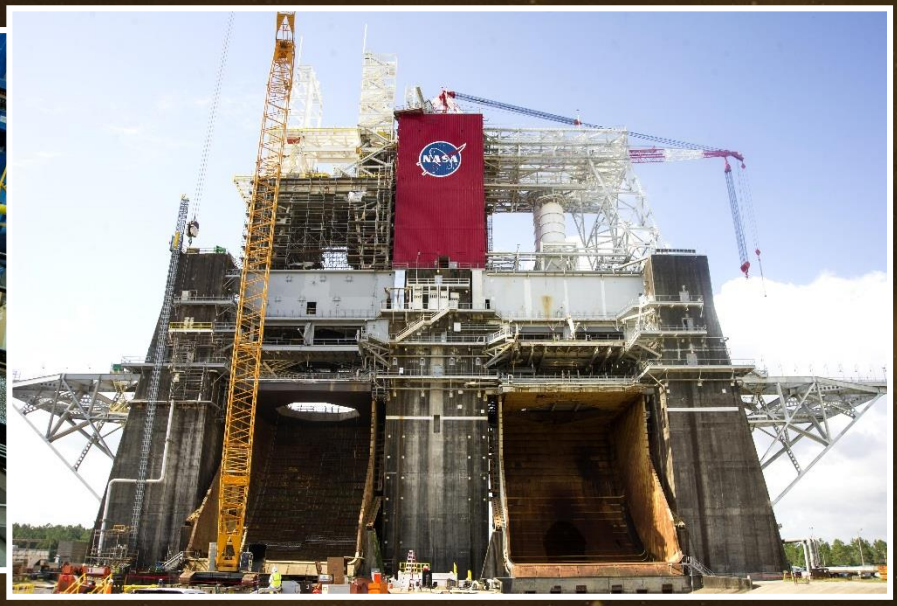
RS-25 Core Stage Engine

RS-25 Controller

RS-25 Adaptation Test, Stennis Space Center, January – August 2015

Core Stage Progress

LH2 Dome Assembly at Michoud, July 2015



B-2 Test Stand at Stennis Space Center

Pegasus Barge Renovation Complete

LH2 Structural Test Article (STA) Test Stand, MSFC, August 2015

SLS MAF/Stages Progress Video

Spacecraft/Payload Integration and Evolution

Orion/MSA Mated to Delta IV for EFT-1
November 2014

DCSS for EFT-1
KSC, June 2014

Systems Engineering & Integration

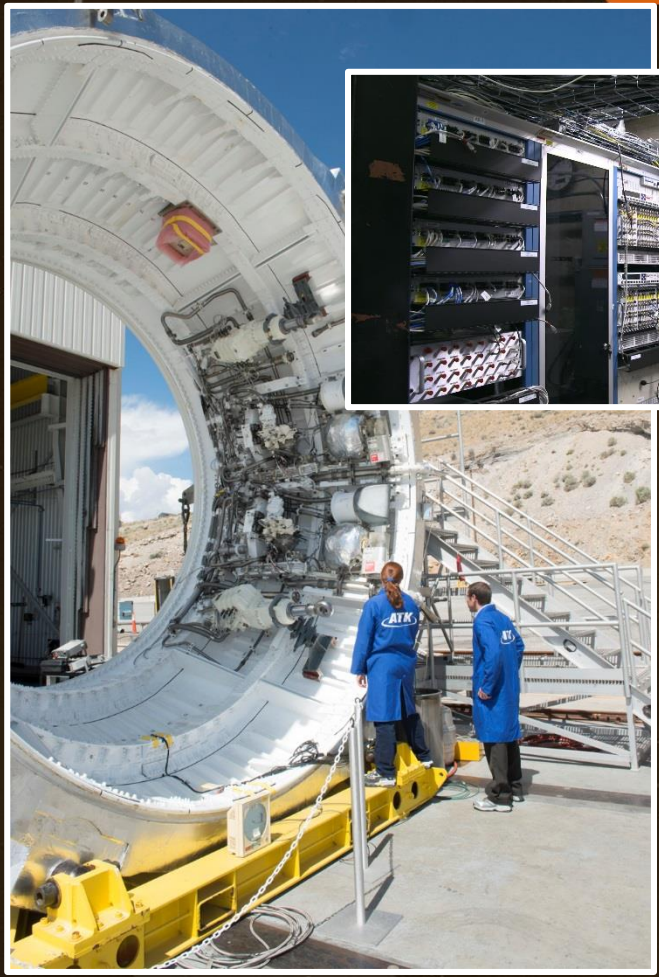
SMAT Testing, MSFC August 2014

Booster Separation Tests, LaRC
October 2014

Core Stage
Engine TVC
Actuator Testing
Redstone Test
Center
March 2015

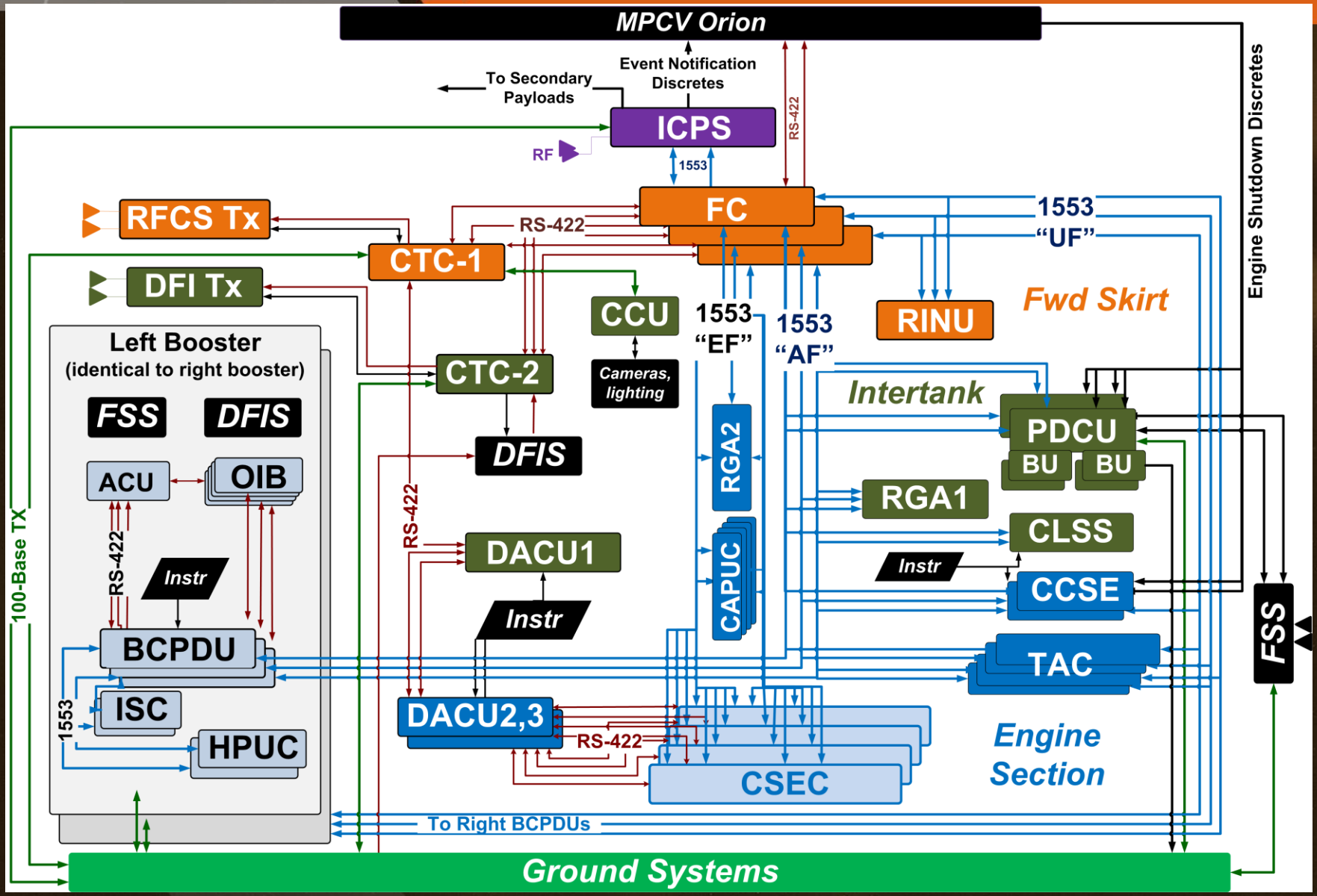
Base Heating Tests CUBRC, Buffalo, New York
January 2015

SLS Avionics Progress

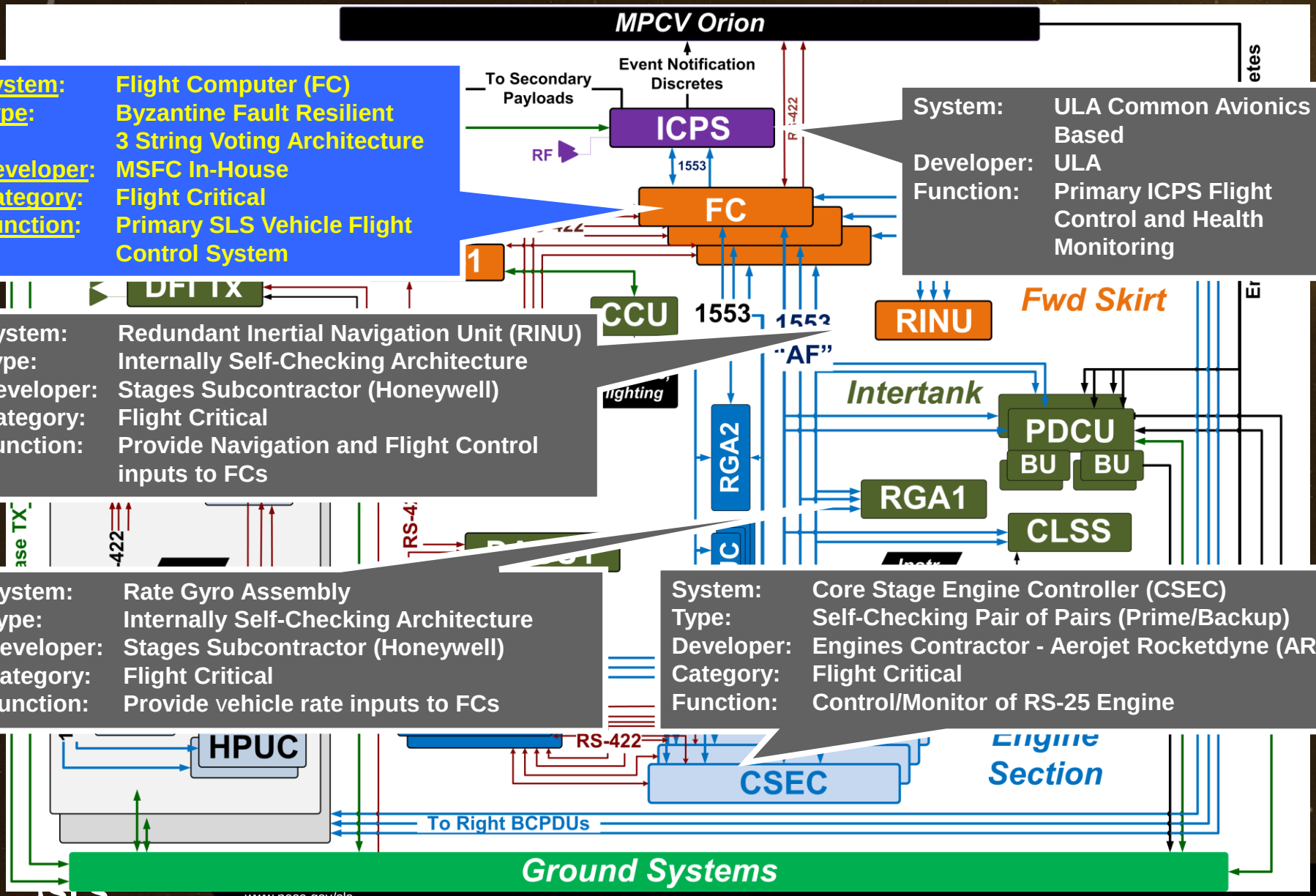


Where is SLS Avionics Located?

SLS Block I Avionics Architecture



SLS Block I Software Providers



System: Flight Computer (FC)
Type: Byzantine Fault Resilient 3 String Voting Architecture
Developer: MSFC In-House
Category: Flight Critical
Function: Primary SLS Vehicle Flight Control System

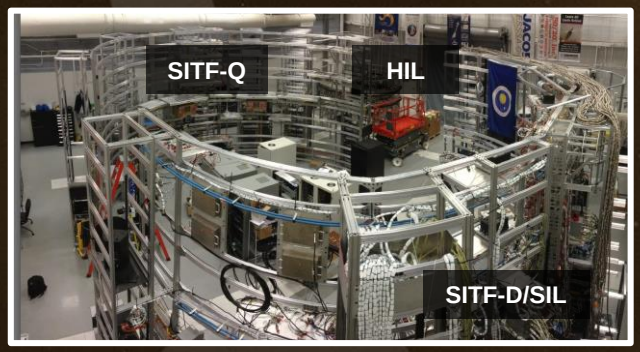
System: ULA Common Avionics Based
Developer: ULA
Function: Primary ICPS Flight Control and Health Monitoring

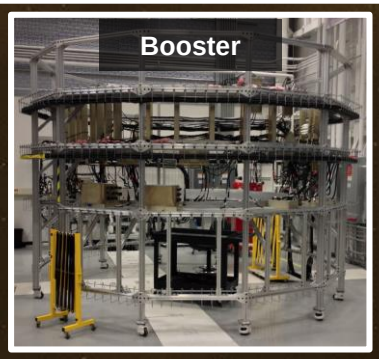
System: Redundant Inertial Navigation Unit (RINU)
Type: Internally Self-Checking Architecture
Developer: Stages Subcontractor (Honeywell)
Category: Flight Critical
Function: Provide Navigation and Flight Control inputs to FCs

System: Rate Gyro Assembly
Type: Internally Self-Checking Architecture
Developer: Stages Subcontractor (Honeywell)
Category: Flight Critical
Function: Provide vehicle rate inputs to FCs

System: Core Stage Engine Controller (CSEC)
Type: Self-Checking Pair of Pairs (Prime/Backup)
Developer: Engines Contractor - Aerojet Rocketdyne (AR)
Category: Flight Critical
Function: Control/Monitor of RS-25 Engine

SLS Block I Avionics and SW Test Labs





SDF-1&2
(FC FSW)

SDF-3
(FC FSW)

Path to EM-1 (First Launch)

2011	2012	2013	2014	2015	2016	2017	2018
Mission Concept Review ✓	System Requirements Review/System Definition Review ✓	Preliminary Design Review ✓	Key Decision Point-C ✓	Critical Design Review ✓		Design Certification Review ▽	Launch Availability ▽

With design and development work mostly complete, the SLS Program is now building and testing components of the world's most powerful rocket to be ready for launch in 2018. Each of these steps advance NASA on the Journey to Mars.

Booster Development Test

Booster Qualification Tests

Boosters Fabrication Complete

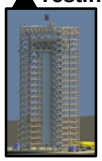
Booster Assembly at KSC

Engines Delivered to Inventory

RS-25 Development Testing Begins

RS-25 Flight Testing Begins

Core Stage Assembly Complete



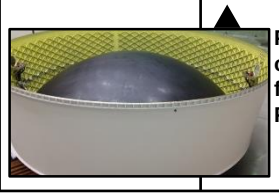
Core Stage Structural Testing

Core Stage Test-Firing

Manufacturing Tooling Installation

Core Stage Production Begins

SLS Design Chosen



Production of Adapter for Orion Flight Test

Upper Stage Production Begins

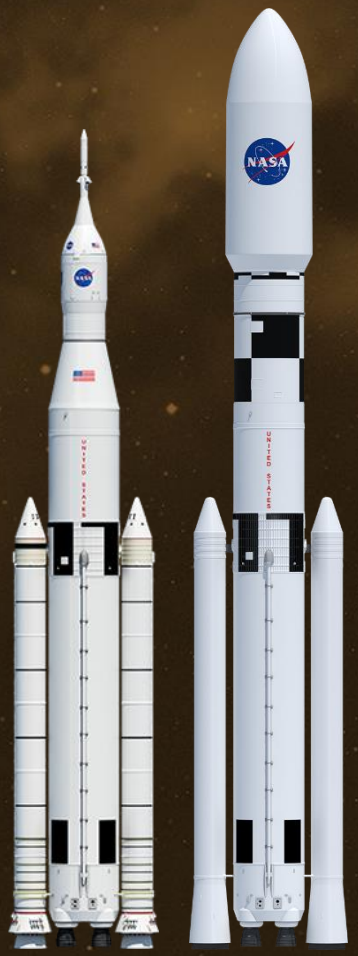
Integrated Upper Stage Structural Testing

SLS Launch Readiness

Concept Studies	Design & Development	Final Design & Fabrication	System Assembly, Integration and Test, Launch Checkout

Summary

- **SLS provides capability for human exploration missions.**
  - Block 1 configuration enables initial flight tests.
  - Evolved configurations enable missions including humans to Mars.
- **SLS offers unrivaled benefits for a variety of missions.**
  - Block 1 provides greater mass lift than any contemporary launch vehicle; Block 2 offers greater lift than any launch vehicle, ever.
  - With 8.4m and 10m fairings, SLS will over greater volume lift capability than any other vehicle.
  - Updated Mission Planner's Guide provides capabilities information.
- **SLS is currently on schedule for first launch.**
  - Critical design review completed in July 2015; SLS is now in implementation phase.
  - Manufacture and testing are currently underway.
  - Hardware now exists representing all SLS elements.



SLS will be the Biggest and Most Capable Rocket ever Built

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Questions?